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of succession near Coram than this latest addition to the already voluminous history of the island.

NORMAN TAYLOR

A NEW CLASSIFICATION OF SOIL MOISTURE[1]

One of the most important and unfortunately also one of the most complex ecological problems is that of soil moisture. The time has passed in which data on soil moisture alone were considered of value. We need to know the water available to plants, not merely the total quantity. Pending the formulation of basic physical principles of soil moisture some method must be used for separating the available from the unavailable water. It is now pretty generally recognized that for any given soil the water unavailable to plant roots is a fixed quantity which to all intents and purposes is a constant depending on the physical properties of the soil. This quantity Briggs and Shantz[2] have called the wilting coefficient. The reviewer is not unaware that acceptance of the wilting coefficient is not complete, and that there is still a tendency to consider it correlated with atmospheric conditions as shown by Caldwell[3] and by Shive and Livingston.[4] Yet a mass of data, some published and some unpublished, show that plants wilt when the soil water has been reduced to a certain rather definite point, regardless of the rate of evaporation. It is true that high evaporation to which a plant is not adapted will cause it to wilt while there is still available water in the soil. If the change is sudden enough, a plant can be made to wilt in water culture. Shull's work on the water-withholding power of soils[5] shows that when the water has been reduced to a certain point the force necessary to extract small additional quantities increases very rapidly. The curve of increasing force with decreasing water is very sharp, as shown on page 25 of Shull's paper. Thomas, in a valuable paper on the "Aqueous vapor pressure of soils,"[6] gives curves showing an equally sharp drop in vapor pressure when the soil moisture decreased to a point which corresponded approximately with the wilting coefficient (pp. 421 and 422). It is evident, then, that considerable differences in pull exerted by the roots of different species of plants would not materially affect the percentage of water left at permanent wilting.

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[1] Bouyoucos, George, "A New Classification of the Soil Moisture." Soil Sci., Vol. 11, No. 1, pp. 33–47, 1921.

[2] Briggs, L. J., and Shantz, H. L., "The Wilting Coefficient for Different Plants and Its Indirect Determination." U. S. Dept. Agr., Bur. Plant Industry, Bull. 230, 1912.

[3] Caldwell, J. S., "The Relation of Environmental Conditions to the Phenomenon of Permanent Wilting of Plants." Physiological Researches, Vol. 1, No. 1, pp. 1–56, 1913.

[4] Shive, J. W., and Livingston, B. E., "The Relation of Atmospheric Evaporating Power to Soil Moisture Content at Permanent Wilting in Plants." Plant World, Vol. 17, pp. 81–121, 1914.

[5] Shull, Charles A., "Measurement of Surface Forces in Soils." Bot. Gaz., Vol. 62, No. 1, pp. 1–31, 1916. Reviewed in Journal of Forestry, Vol. 15, No. 1, pp. 110–117, 1917.

[6] Thomas, Moyer D., "Aqueous Vapor Pressure of Soils." Soil Science, Vol. 11, No. 6, pp. 409–434, 1921.

The water in the soil has generally been divided into gravitational, capillary, and hygroscopic. But Briggs and Shantz's work show that part of the so-called capillary water is available and part unavailable to plant roots. The water left at permanent wilting includes much more than the hygroscopic moisture, although Alway has shown that even some of the hygroscopic water may have a high value for the maintenance of life in certain desert legumes.[7]

Bouyoucos has developed a new classification based on the freezing point lowering of the different portions of soil moisture determined by the dilatometer method. This classification is as follows:

- Gravitational
- Free
- Unfree
  - Capillary-adsorbed
  - Combined
    - water of solid solution or
    - water of hydration

The gravitational water needs no comment. The free water is that which freezes for the first time at a temperature of —1.5° C. The capillary-adsorbed water is that which freezes finally at the supercooling of —4° C. and lower. The combined water does not freeze at all even at —78° C.; this is the water of hydration in the soil colloids.

Determinations were made of the percentages of water which came under the above categories, except gravitational, in 73 soils. As was to be expected, the heavier soils contained the larger percentages of unfree water and smaller percentages of free water. The unfree water ran from 0 in quartz sand, and 4 percent in coarse sand, to 84 percent in Minnesota Superior Clay and in Cecil Clay from Jackson County, Louisiana. The percentages are constant for any given soil.

A direct comparison between the wilting coefficient and dilatometer results shows that the percentage of moisture which fails to freeze at —1.5° C. agrees very closely with that at which plants begin to wilt, "indicating that the wilting coefficient of soils is at the point where free moisture ends and the capillary-adsorbed moisture begins."

It is significant that Bouyoucos arrived, by an entirely different route, at practically the same position as Briggs and Shantz. The author states (p. 43) that in the light of the dilatometer results we see that plants wilt at the wilting coefficient, not because the rate of movement of soil moisture is too slow, but because it does not move at all. (See also Journal of Forestry review cited in footnote 5, p. 116.)

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[7] Alway, F. J., "Studies on the Relation of the Non-available Water of the Soil to the Hygroscopic Coefficient." Univ. of Neb. Agr. Exp. Sta. Research Bull. 3, 1913.

In spite of the correlation which he found between his dilatometer results and the wilting coefficient, the author states that determination of the wilting coefficient by means of the plant, besides being tedious and time-consuming; is not accurate nor constant. He accepts the misconception, based on the work of Caldwell and of Shive and Livingston, that "permanent wilting is a function of atmospheric evaporation," discussed in the first paragraph above. This, however, bears only on his argument that the dilatometer offers a better method of determining unavailable moisture than direct determinations by use of plants.

On the whole, the work is of much significance in the conception of soil moisture presented and in giving another method of measuring the unavailable water of soils.

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